Zhanna Kuhrij

Colliding a New Type of Liquid

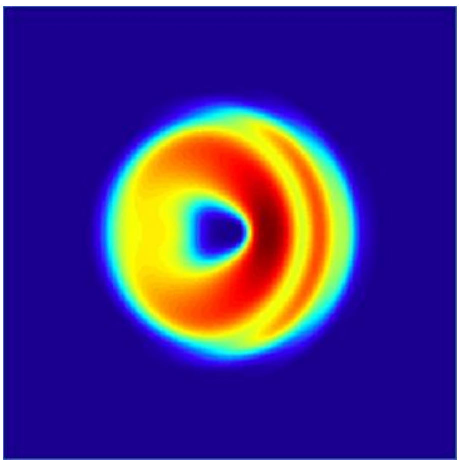
The difference between a gas and a liquid is relatively simple. A gas fills the whole space available to it, while a liquid does not necessarily. Gasses also usually have lower densities than liquids. Now, imagine a mixture of atoms that has orders of magnitude lower density than air, but still forms liquid droplets. This new type of liquid was theoretically proposed in 2015 and has since then also been created in the lab. In my bachelor thesis, I studied how this liquid flows past an obstacle.

This new type of liquid is stabilized by quantum mechanical effects. The motion of the objects we see around us, e.g. cars, balls and water waves, are described by *classical mechanics*. The behavior of atoms, electrons and other particles is on the other hand described by *quantum mechanics*. Quantum mechanics is known for counter-intuitive results. For example, particles can move through "walls" and be at several places at the same time. This makes it a very interesting field of study. A practical application that has also come from is for example quantum mechanics is *quantum computers*.

In order to understand how these dilute droplets are formed, one must first know that particles are divided into two groups: *bosons* and *fermions*. Several bosons in a system can at the same time have the same properties, e.g. energy and "rotation", while fermions cannot. Another thing one must know is that when a mixture of atoms, which can either be bosons or fermions, is cooled down, the atoms generally lose energy. If the atoms are bosons and the temperature is lowered to *absolute zero* (-273 °C) or a bit higher, all atoms (or many) can be in the lowest energy state at the same time. This is called a *Bose-Einstein Condensate (BEC)*, and this is what the dilute droplets are made of.

How BECs form dilute droplets is a complicated mechanism. To describe BECs, several approximations have to be made. This is usually the case for a system of several particles, which can be very complicated to model. A central approximation for dilute BECs is *the mean-field approximation*. Even though the particles in such a BEC interact slightly, the mean-field approximation assumes in a way that they do not interact. This makes calculations easier. The dilute droplets are formed using a correction to this approximation, which is based on quantum mechanics.

In my thesis, I thus have studied how these dilute droplets react when they collide with an obstacle, which was similar to a cylinder. A picture of one of the collisions is shown to the right, where dark red is the highest density in the droplet (followed by yellow, orange, green and light blue) and dark blue no density. The obstacle is not directly plotted in the picture, but is placed in the middle of it. The study showed interesting results and there is great potential for future research. Even though this was a theoretical study, which is very interesting in itself, one never knows what practical applications it also might have in the future.



Supervisor: **Stephanie M. Reimann**, Co-supervisor: **Mikael Nilsson Tengstrand**, Bachelor of Science 15hp, 2020, Department of Physics, Lund University.